Tevatron Microwave Schottky

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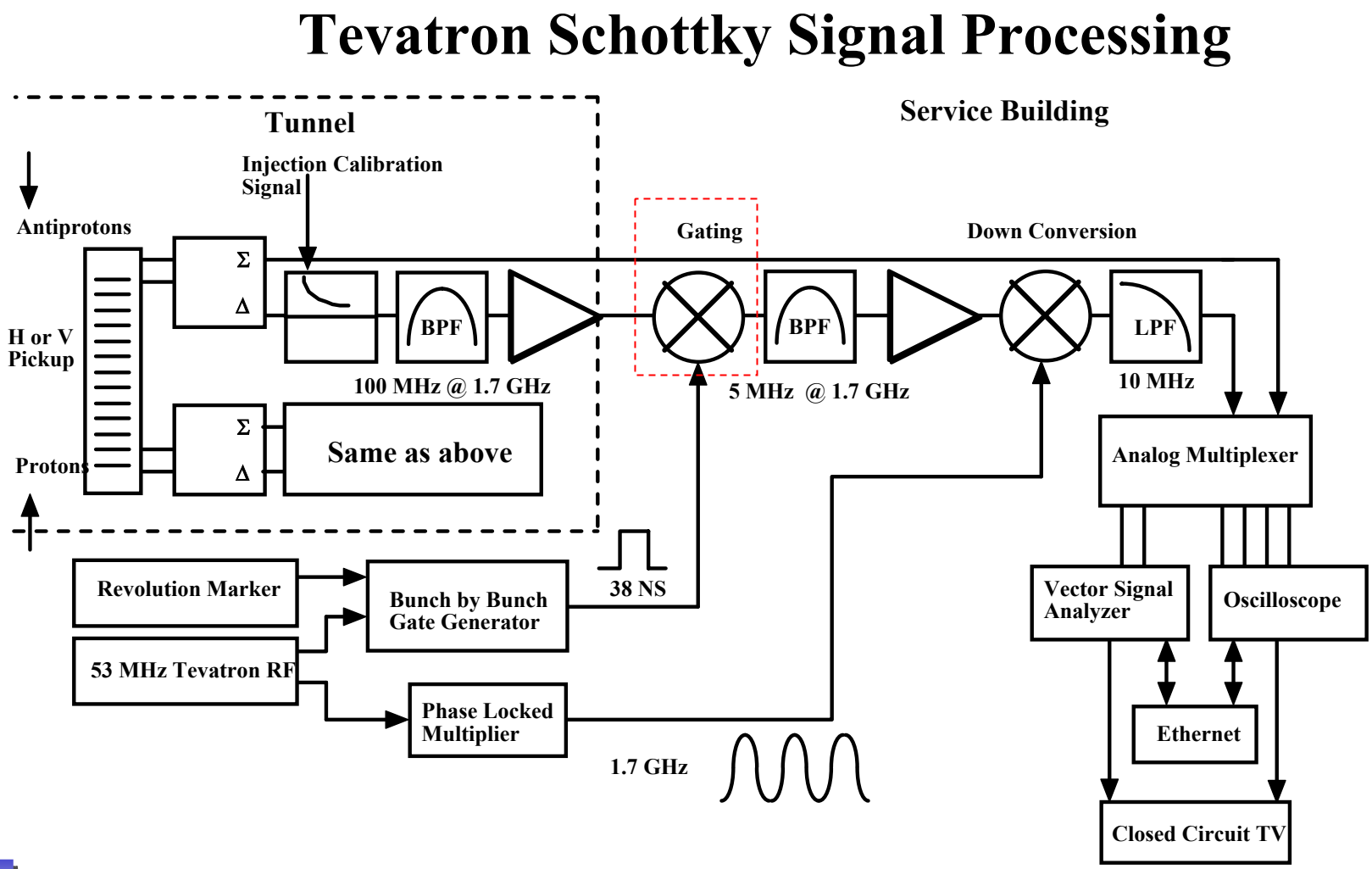
Outline

- System overview
- Recent measurement results
  - Tunes and momentum spreads
  - Emittance and chromaticity
  - Single bunch measurements
- Conclusions and outlook

Hardware overview



Software overview

Log plotter
D44

Java GUI
OAC parameter control

VSA app
direct VSA control
T51

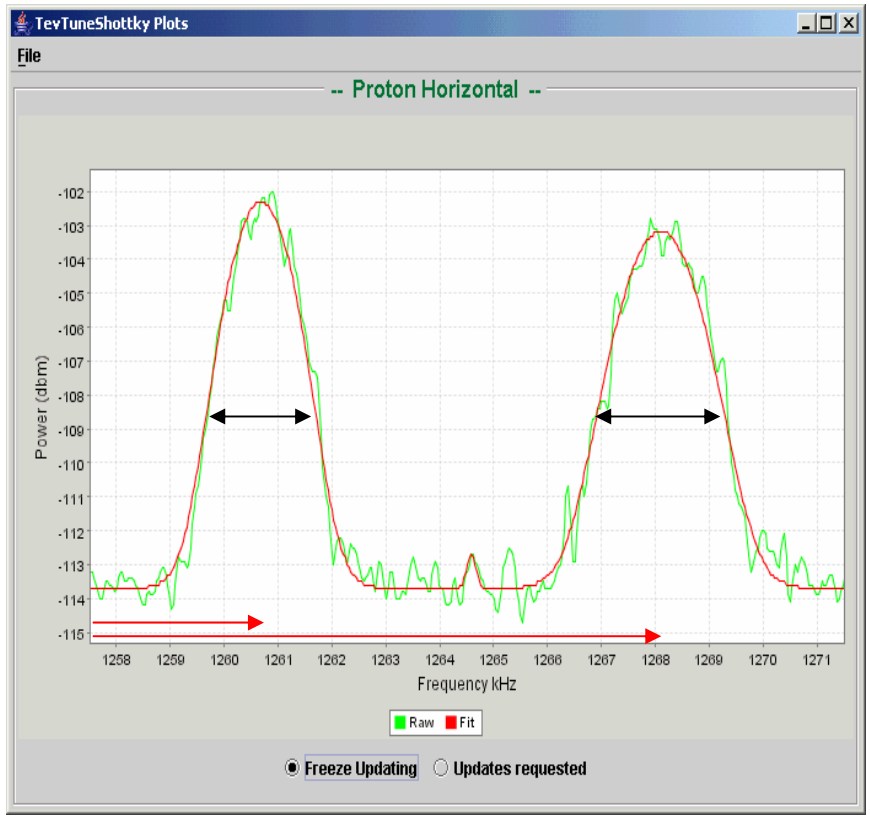
Lumberjack
Data logging of output parameters at various rates

Java/C++ OAC
(Open Access Client)
VSA + gate control, tune fitter, ACNET parameters

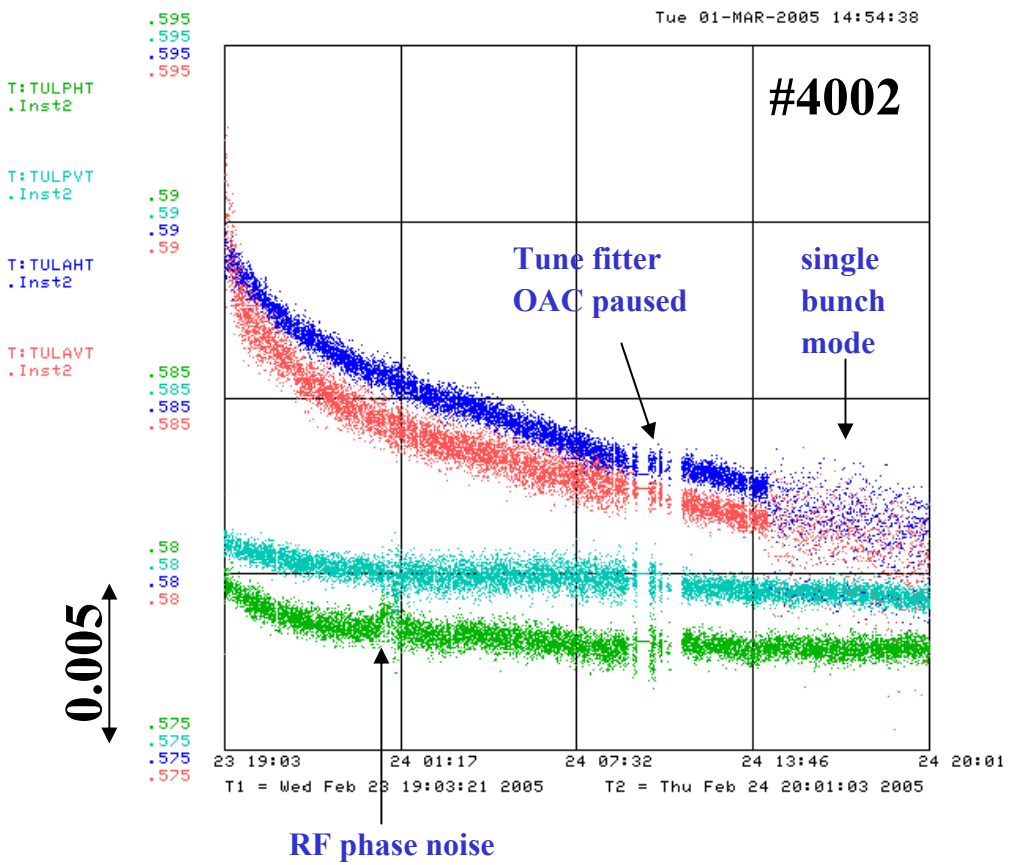
Hardware
Pick-ups, amplifiers, gate generators, VSAs

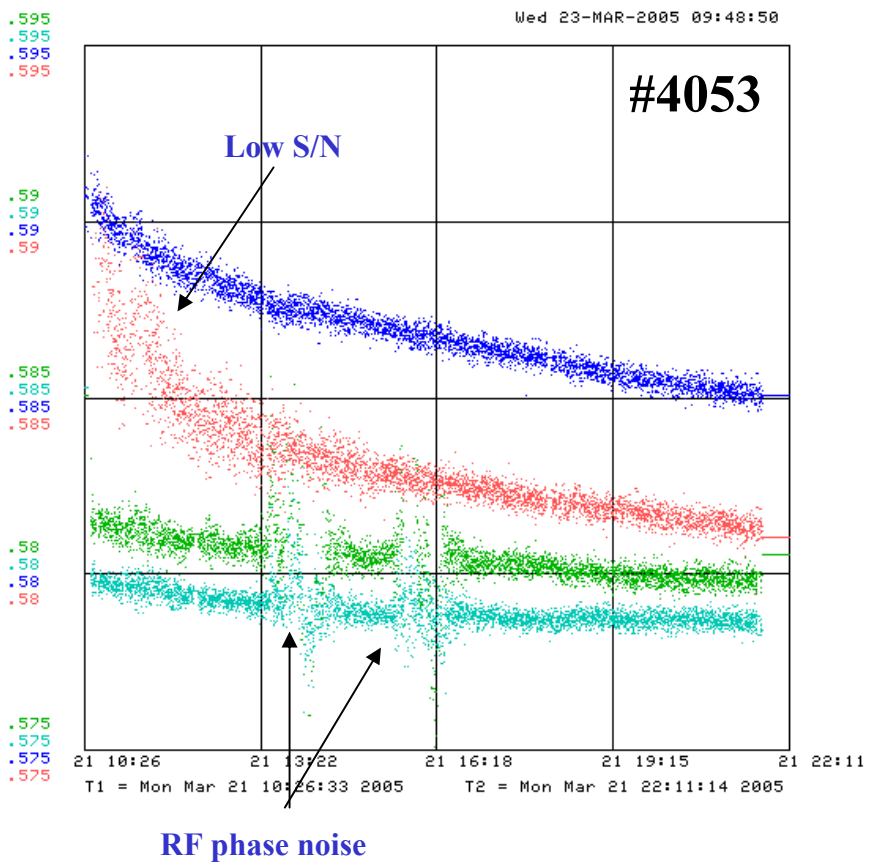
Schottky spectra & analysis

- Tunes from peak positions
- Momentum spread from average width
- Chromaticity from differential width
- Emittance from average band power



Tune during stores

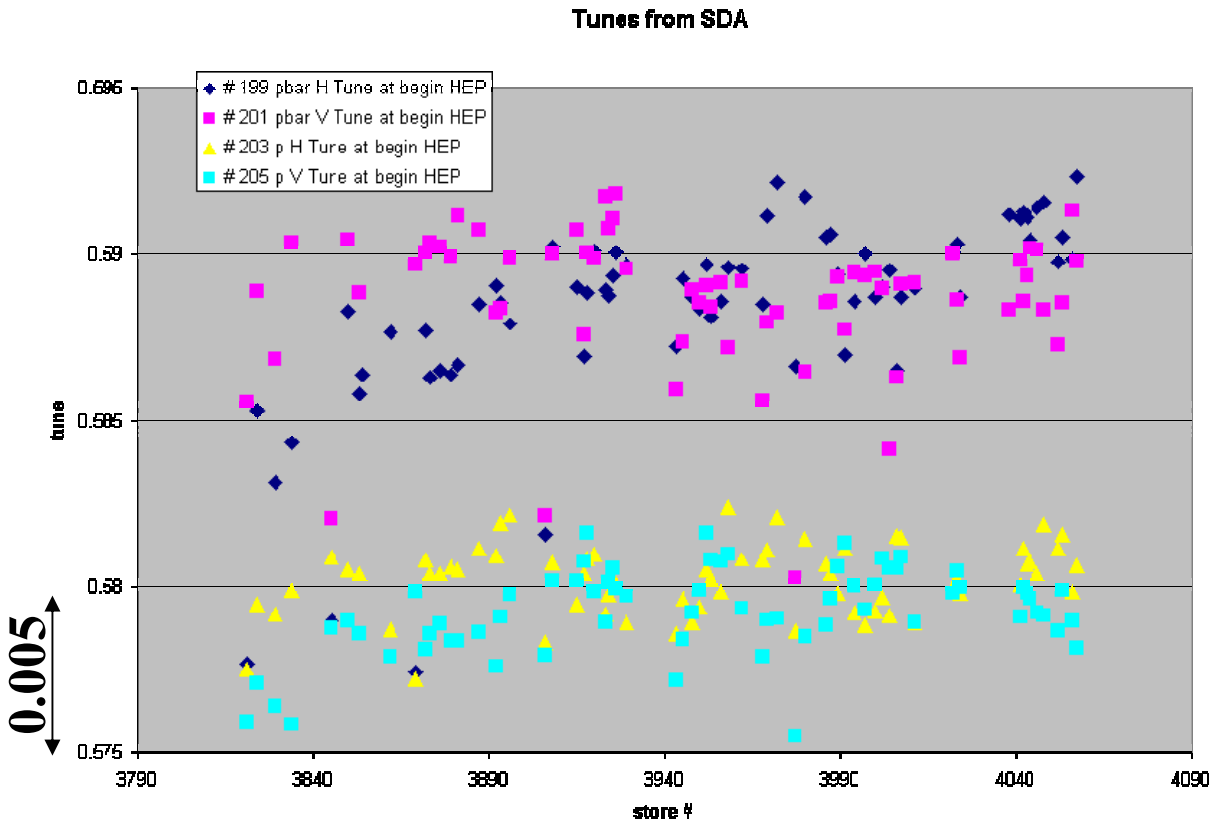




Clearly see beam-beam effect on pbars (and protons).
Plans to make slow feedback base on this data.

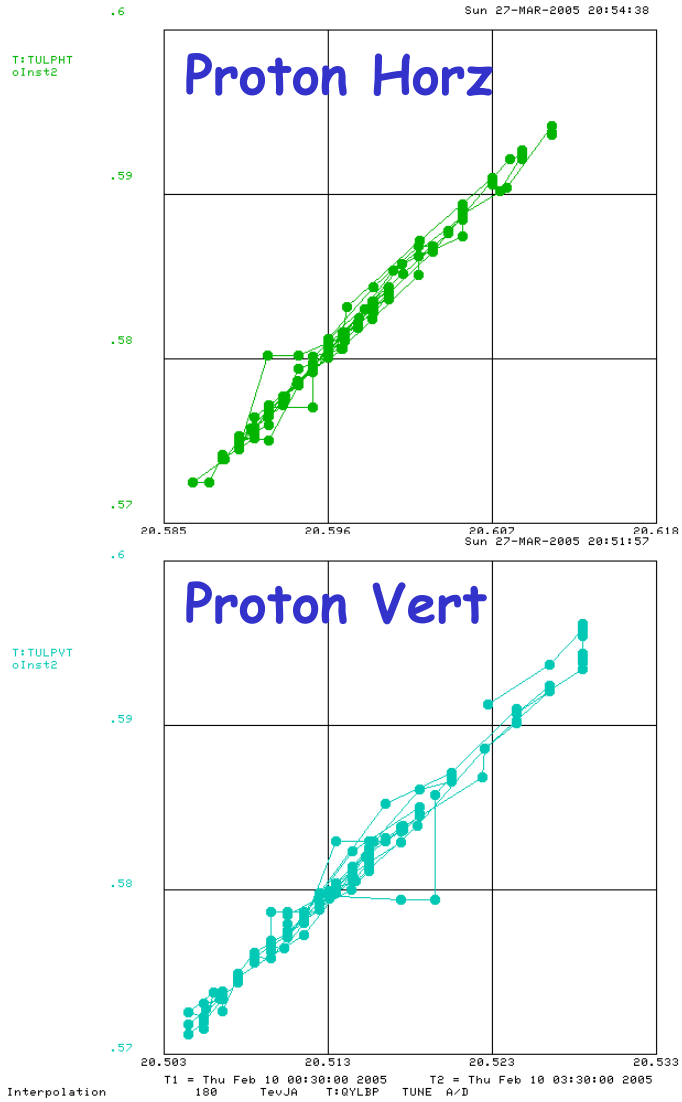
Tev tune history

- Average tunes are logged continuously every store.
- Can use to correlate with efficiencies, lifetimes etc

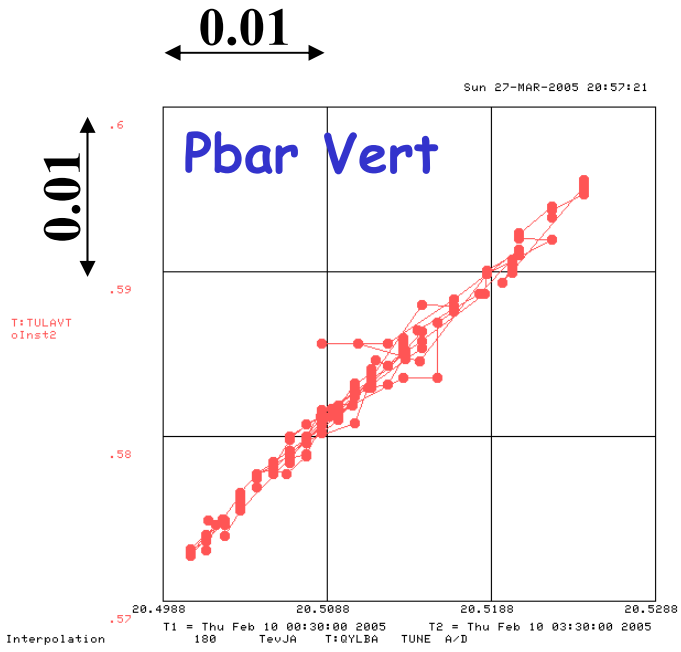


16 week tune history

Tune “tracking”

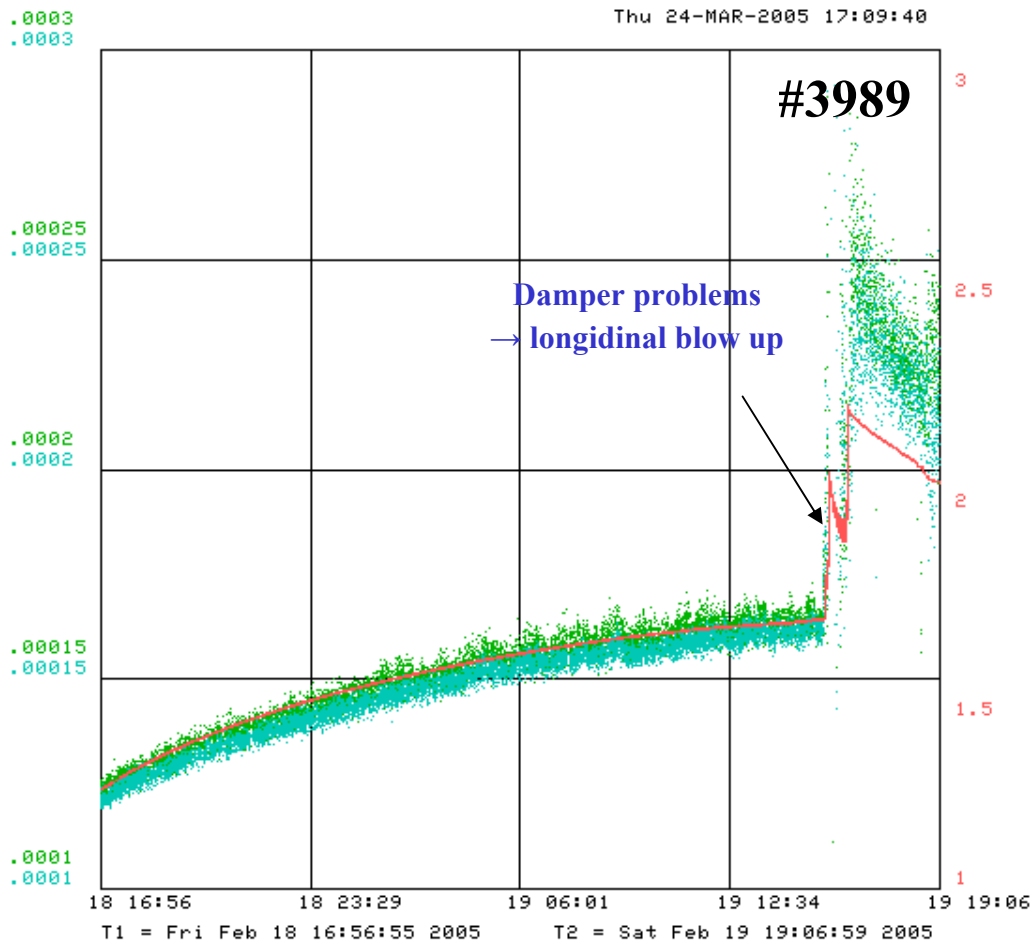


- Measured tune tracks changes in set tunes very well.



Momentum spread

- Momentum spread measurement show good agreement with bunch length measurement.

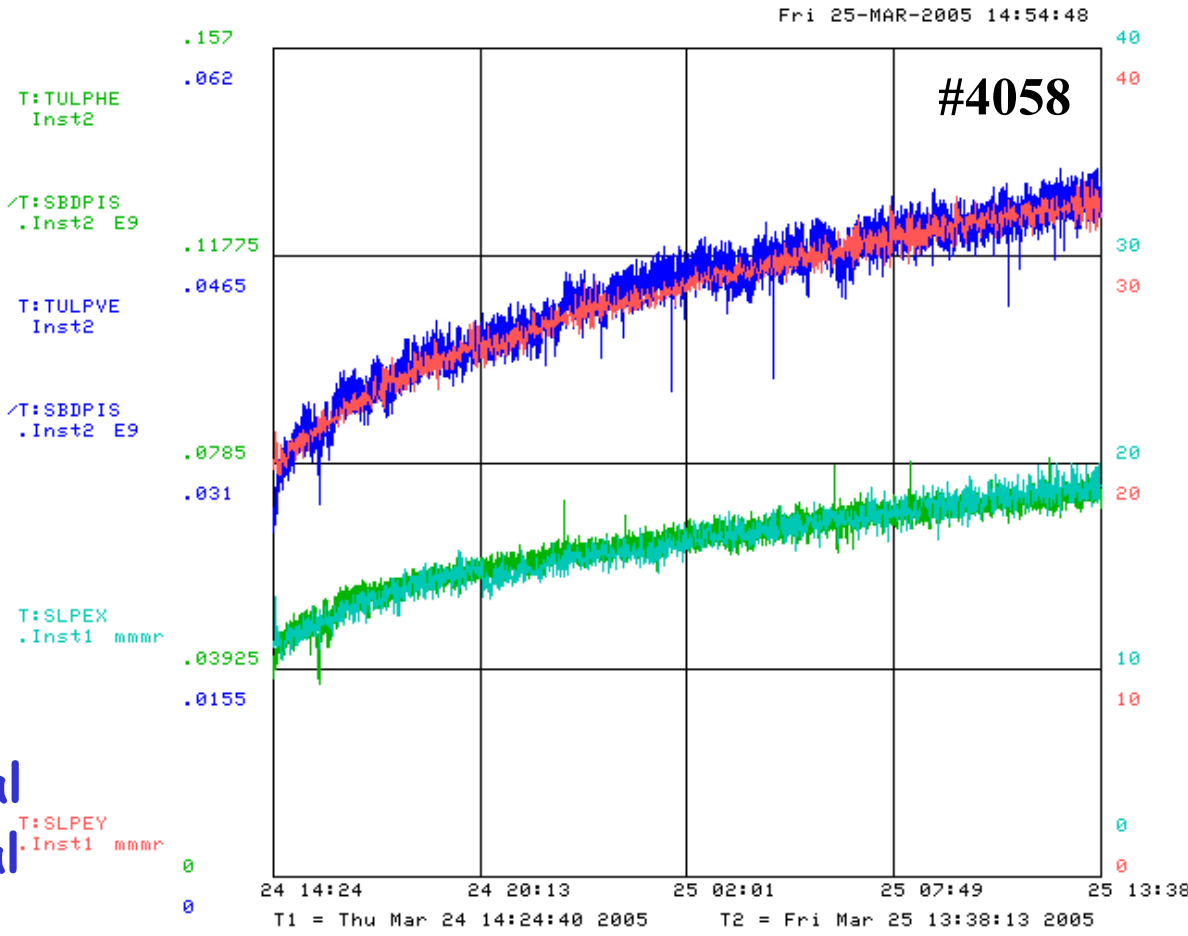


— Horizontal channel
— Vertical channel
— Bunch length (SBD)

NO fudge factors!!!

Emittance

- Qualitative emittance agreement after recent improvements
- Not yet calibrated

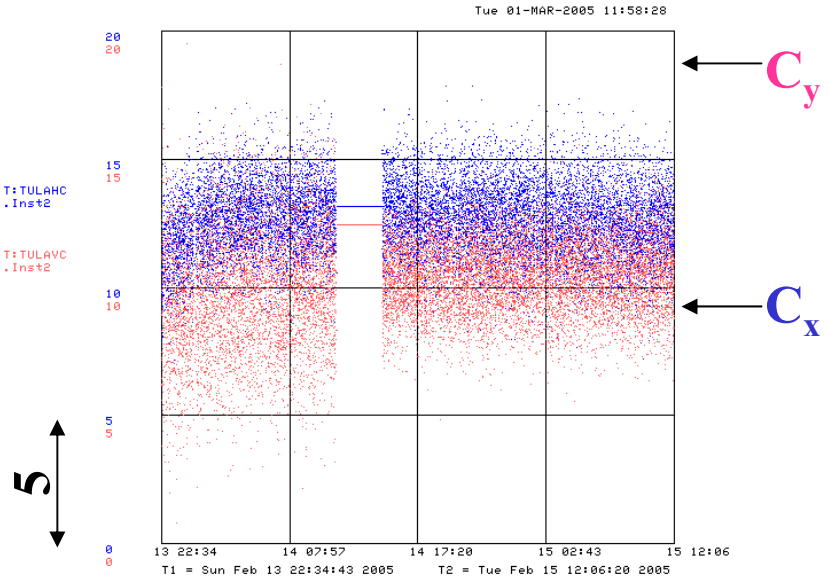


— Schottky Horizontal
— Sync lite Horizontal
— Schottky Vertical
— Sync lite Vertical

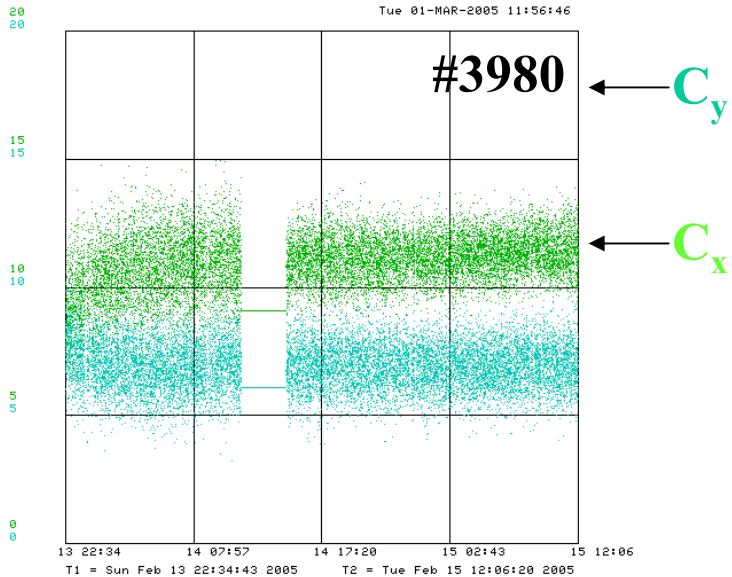
Note: Arbitrary scaling

Chromaticity

Protons

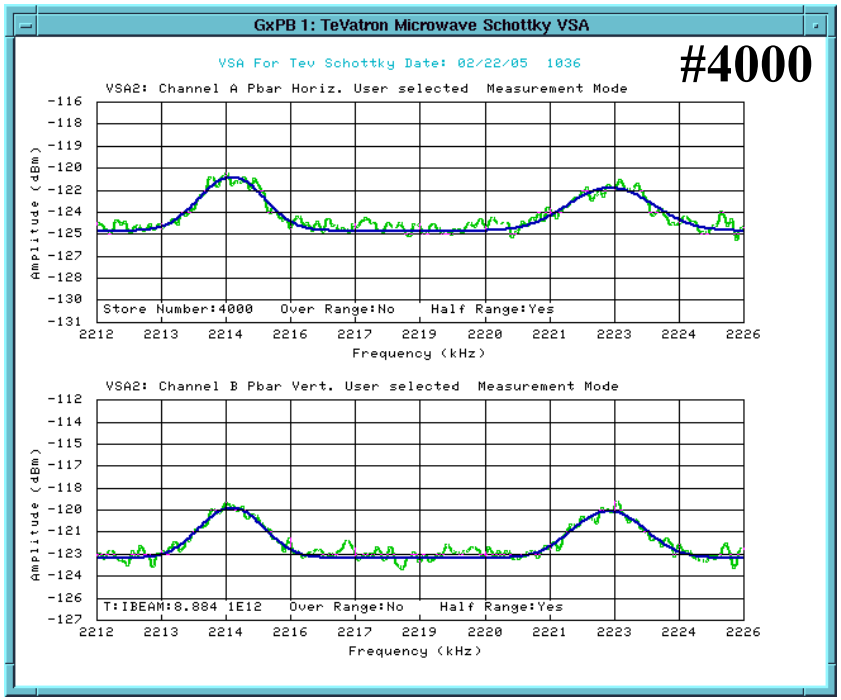


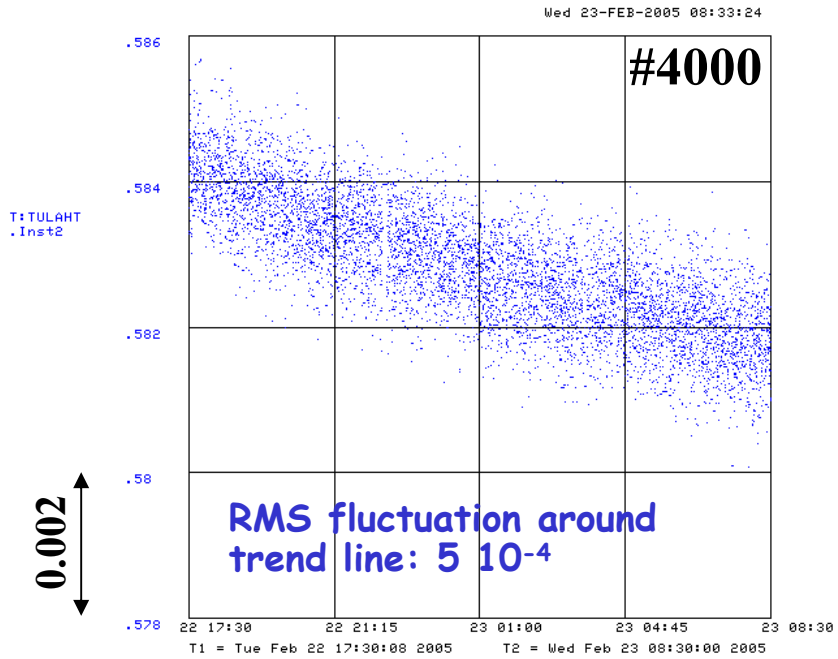
Pbars



- Hard to make parasitic comparative measurements, so systematic study has not yet been done.
- Measured chromaticities during a store and compare to traditional measurement on next ramp (with low intensity, uncoalesced beam).
- Appear to be missing factor ~2 in vertical plane for both species.
- Not yet understood (could be real, could be a instrument problem).

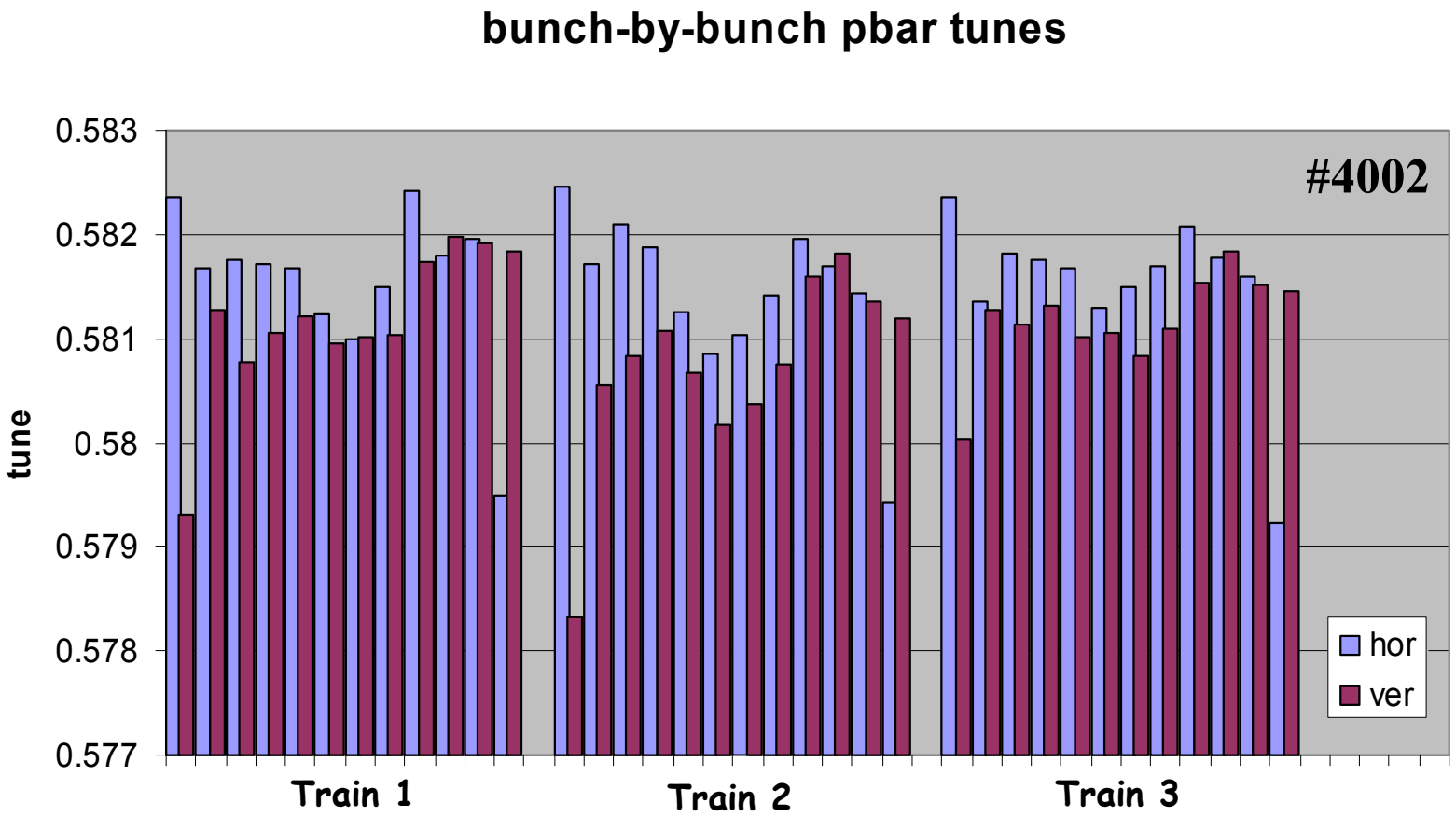
Single pbar bunch measurement





Pbar bunch #29
Intensity: 19 10^9
Emittance: ~17 π mm mrad

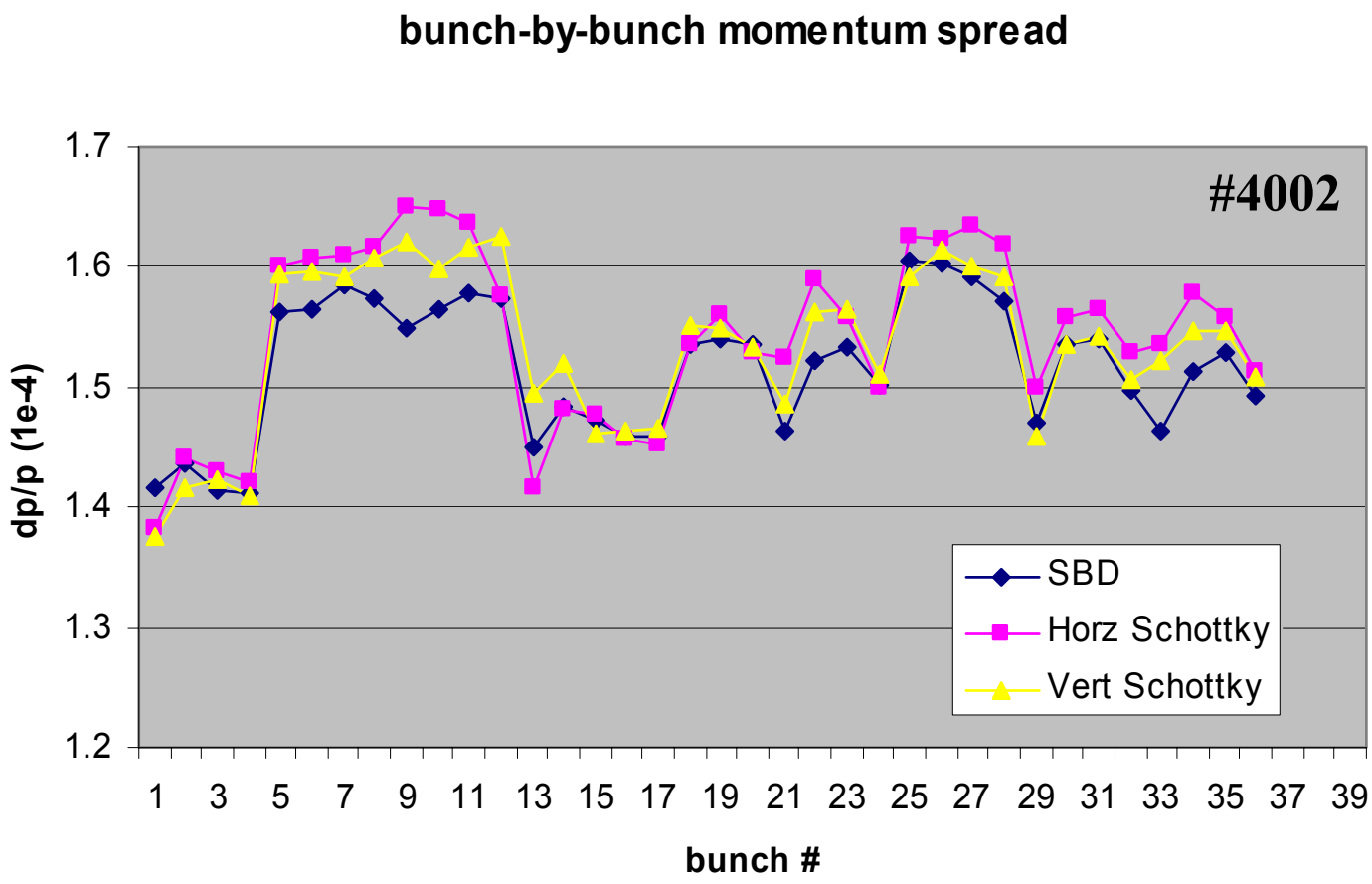
Single bunch tunes



Bunch intensities: 15-40 10^9 Emittances: 7-17 π mm mrad

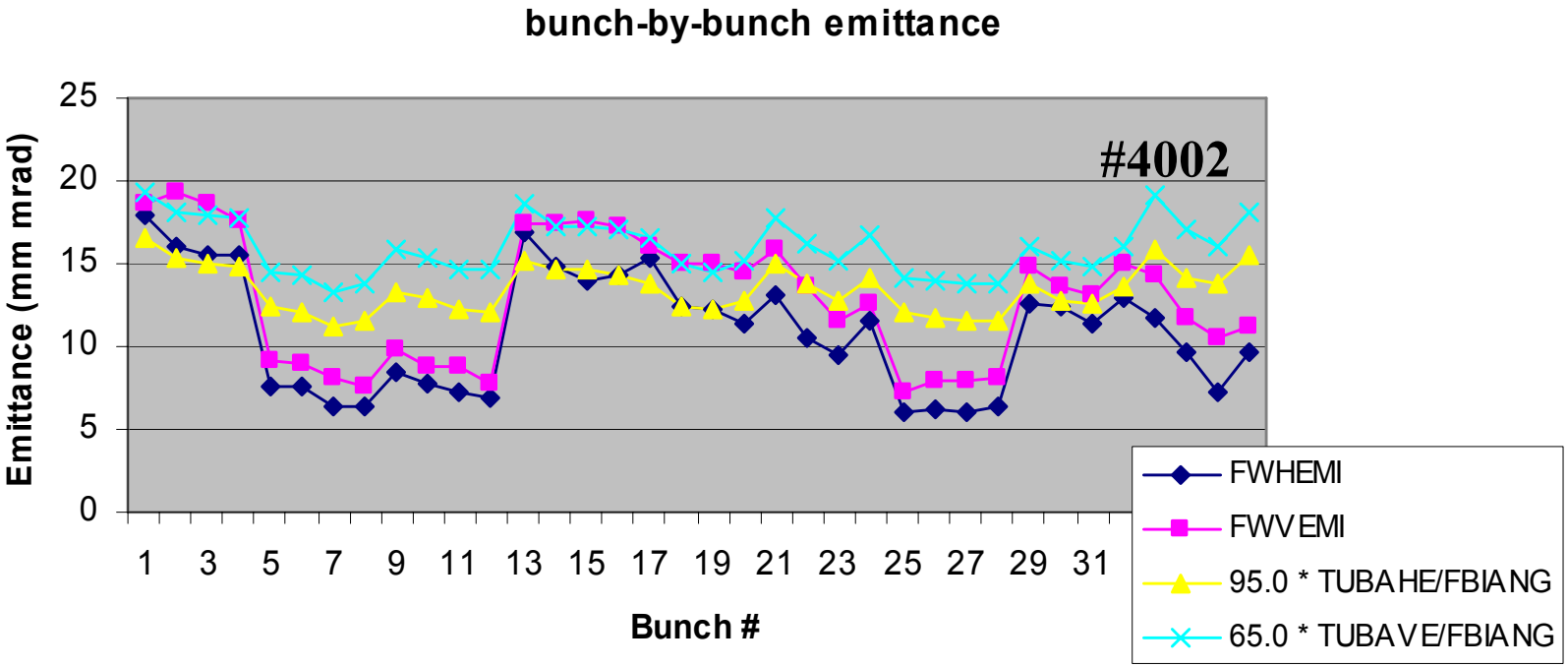
Note characteristic beam-beam signature on first and last bunches in each train!

Single bunch momentum spreads



NO fudge factors!!!

Single bunch emittance



NB. Wire fly was several hours before Schottky measurement!

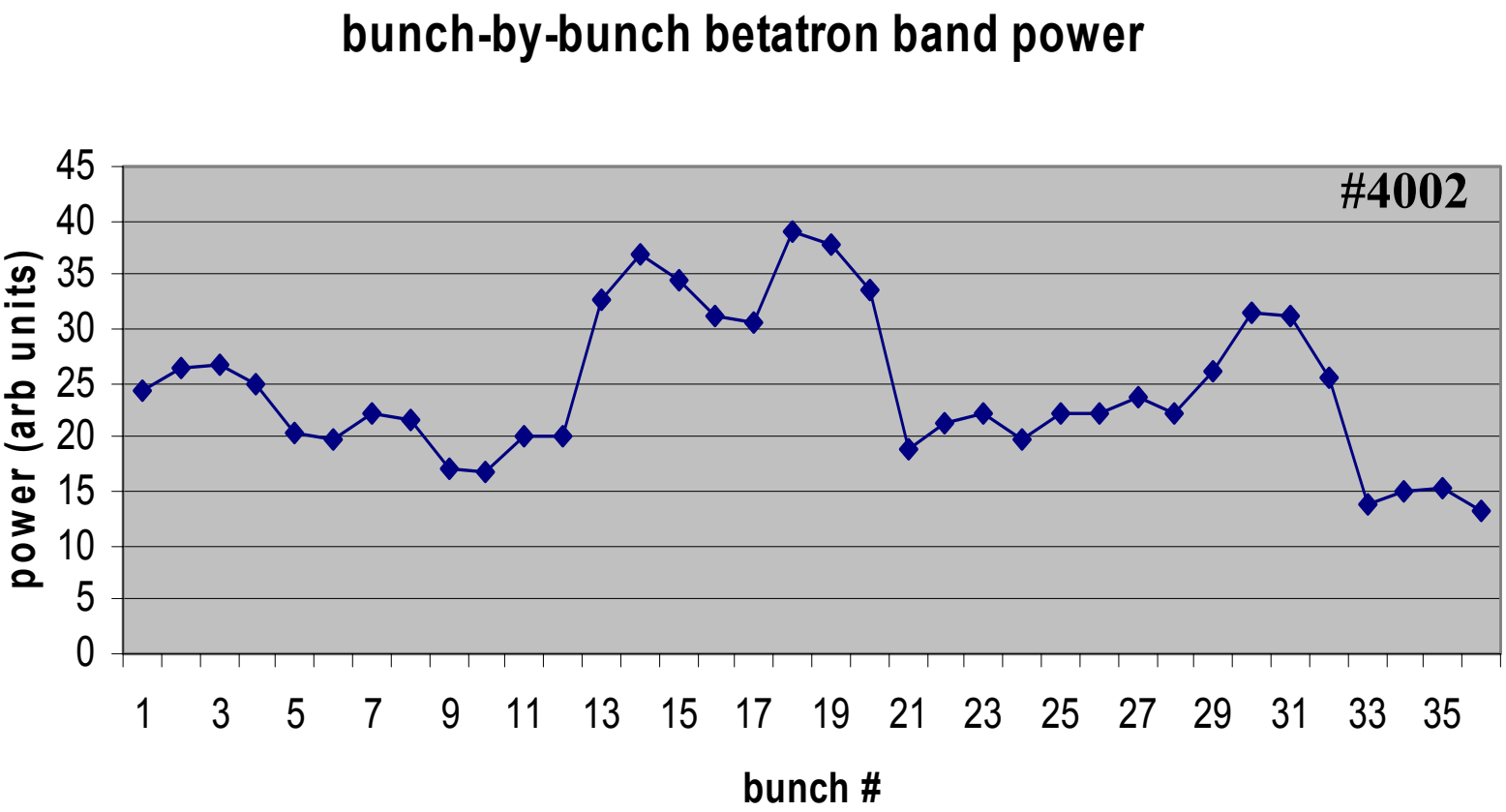
Schottky emittance scale uncalibrated (arbitrary scaling).

Conclusions

- 1.7 GHz Schottky tunes are measured and logged continuously during stores.
- Considering implementing slow tune feedback based on this data.
- Very good momentum spread agreement.
- Qualitative emittance agreement. Not yet calibrated.
- Chromaticity measurement need more work.
- Can measure tune of a single 15 10^9 pbar bunch to 5 10^{-4}!!!

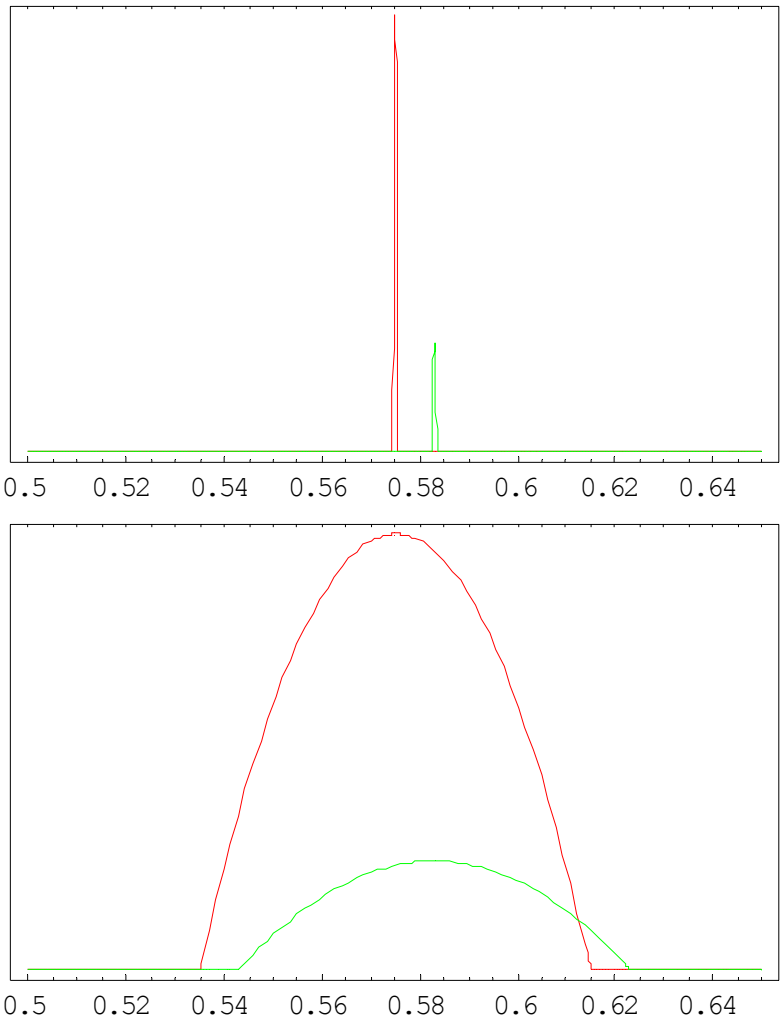
Back up slides

Single bunch emittance



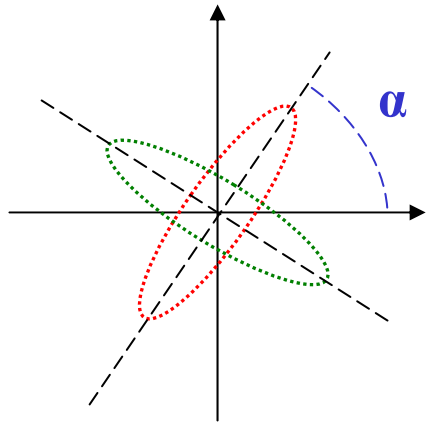
High frequency vs low frequency Schottky

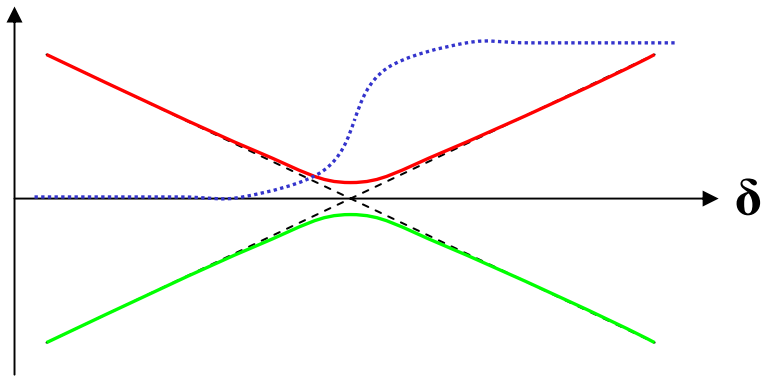
- In a low frequency Schottky spectra, can separate normal modes by frequency
- Microwave Schottky rely only on directional (hor/ver) sensitivity.



Simple coupling theory

- Measured tune is a weighted average of the two modes.
- Weight is given by inclination angle α.
- Tends to bring measured tunes back together.
- Cancels coupling tune separation exactly in simple model.
- "We measure <u>set</u> tunes"





http://beamdocs.fnal.gov/cgi-bin/public/DocDB/ShowDocument?docid=1576

Coupling observations

- Difference in measured tunes from 21MHz and 1.7 GHz Schottky show effect of coupling.
- More detailed analysis to follow, using e.g. measured coupled beta functions.

NB. Coupling affects emittance and chromaticity as well